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CERATOPHYLLUM DEMERSUM IN WEST OKOBOJI LAKE

EDWARD N. JONES

Ceratophyllum demersum L. grows luxuriantly in West Okoboji Lake, Dickinson County, Iowa, and occupies an important place in the life program of its waters. During the summers of 1922-23 investigations were made relative to its distribution, position in the macrophytic zone, and general biology. The work was done with the aid of facilities offered by the Iowa Lakeside Laboratory situated on the west side of the lake at the head of Millers Bay.

DESCRIPTION

Ceratophyllum belongs to that interesting biological group of the Angiosperms which have solved the numerous problems associated with the submersed habitat. The dissected leaves, slender stems, total lack of roots, and submersed pollination give abundant evidence of a long association with water.

The genus is the only one in the family Ceratophyllaceae of the order Ranunculales. *Ceratophyllum demersum* is commonly known as the hornwort but other names are frequently used such as hornweed, morass-weed, fish blankets, coontail moss and coontail.

The vegetative organization (Figure 1) follows a distinct nodal and internodal plan with each node bearing a whorl of five to twelve filamentous leaves, usually twice or thrice forked. A compact and almost bud-like tip is formed, both on the main axis and lateral branches, by the imbrication of the leaves due to shortness of internodes in the apical region.

Ceratophyllum does not possess roots but the basal end of the main axis and attached lateral branches may be buried in the substratum. The degree of anchorage seems to be largely dependent upon the nature of the bottom over which the plants grow. In West Okoboji most of them are over soft mud and are so efficiently attached that they resist removal as much as do many of the rooted Angiosperms. In fact, *Myriophyllum* with its numerous roots, is found floating at the surface more frequently than is *Ceratophyllum.*

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SHORE CONFIGURATION OF THE LAKE

The glacial origin of West Obokoji together with strong wave action, has produced an irregular shore, replete with both exposed and sheltered portions. The long axis lies nearly parallel to the direction of the prevailing winds resulting in the subjection of a large part of the shore line to the work of waves during the open season and to the push of ice in late winter and early spring.

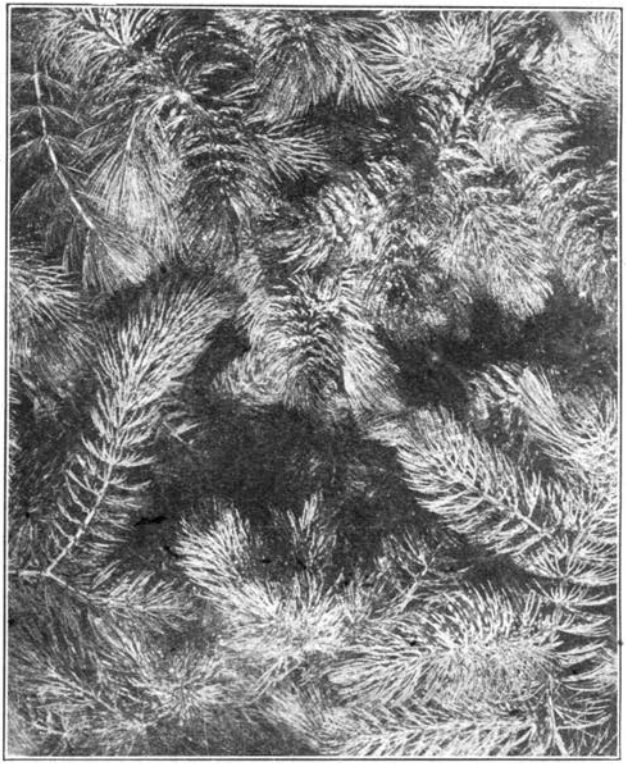

Fig. 1. Dense growth of *Ceratophyllum demersum* as seen through water from above. View typical of the beds in Millers and Emersons Bays

The shores are for the most part of medium relief but the high and precipitous and marsh types are also represented. The type of shore has a distinct bearing upon the kind and quantity of vegetation growing in the waters adjacent. The north and south ends and parts of the west side have very low shores with marsh land adjoining. The precipitous type is found chiefly on the east side although not exclusively.

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A SURVEY OF THE MAROPHYTIC AREA

The study of the distribution of *Ceratophyllum* necessitated a survey of the areas supporting major vegetation. One hundred and ninety-six stations were established along the 29.3 kilometers (18.2 mi.) of shore line, the average intervening distance being 149.5 meters. The composition of the plant zones at each station was determined by dredging to the outer limit of vegetation along a line placed generally at a right angle to the shore. The water was usually clear enough to permit the recognition of plants growing in depths up to two meters and beyond the limit of visibility a many pronged hook was used for dredging. A calibrated and weighed line was the means of securing depth measurements. The distance out from shore and along shore between stations was determined by the use of The Hymans Pocket Range Finder, an instrument rated as giving results with about five per cent error. Notes were taken of the plants at each station and their position, both as to depth and distance from shore. Definite location of the beds of *Ceratophyllum* was quite easily made for the shoreward and outer margins are usually clear cut. Other seed plants and also the Characeae were taken into account for the purpose of determining the relationship betwen them and *Ceratophyllum.*

DATA OF THE SURVEY

The distribution of *Ceratophyllum* in West Okoboji lake is indicated by the stipled areas in Figure 2. The lines extending out from the shore are the stations of the survey. The plant covers 434 acres (175.5 hectares)[1] or 11.5% of the total area of the lake, Table I. The west half of the shore line is more favorable to vegetation than is the east half, due to the larger amount of bay area and the less precipitous open shores. The latter, with rapidly sloping and sandy substratum, has less than one-fourth of the total acreage of *Ceratophyllum.*

TABLE I

ACREAGE OF *CERATOPHYLLUM* IN (1) ENTIRE LAKE. (2) WEST HALF. (3) EAST HALF. THESE INDICATED ALSO IN TERMS OF PER CENT OF TOTAL AREA OF *CERATOPHYLLUM* AND OF TOTAL AREA OF LAKE.

Portion of Lake	Acreage of Ceratophyllum	Percent Total Area Ceratophyllum	Percent Total Area Lake*
(1) Entire	434	100	11.45
(2) West half	338	78	9.19
(3) East half	96	22	2.26

[1] For comparative size of acre and hectare see scale, figure 2.

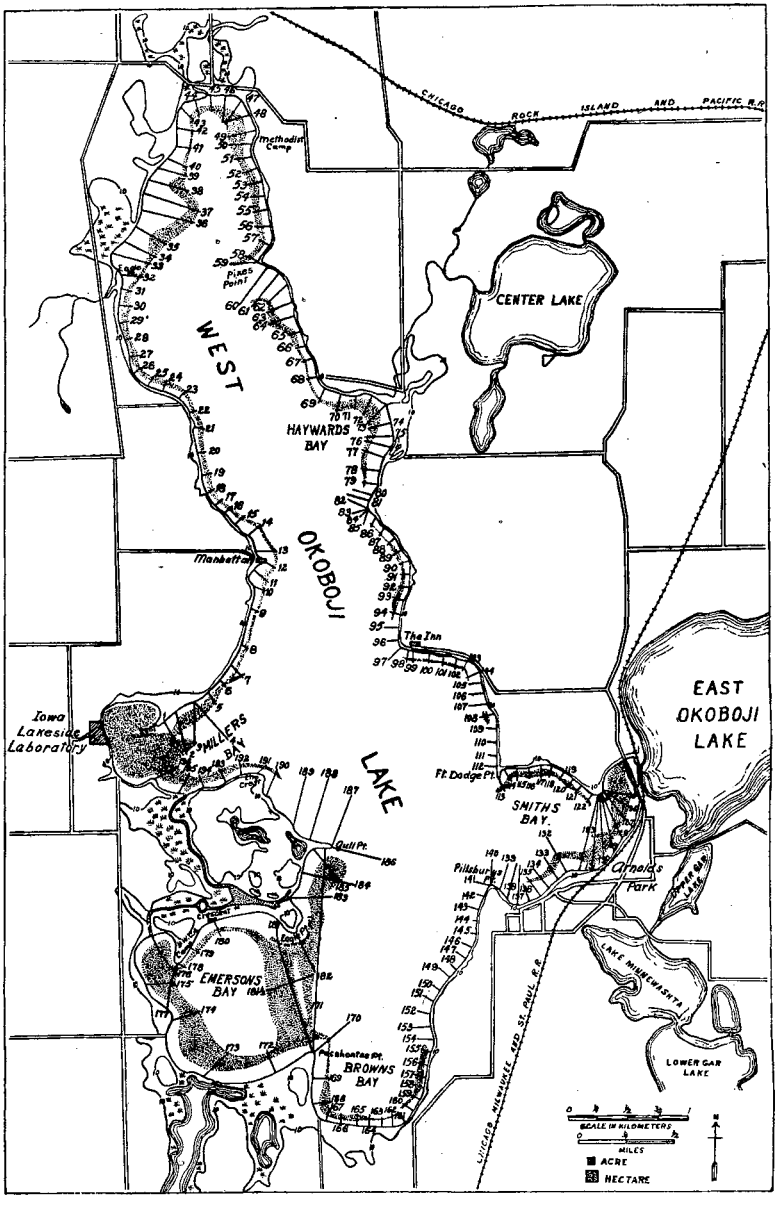

Fig. 2. Map of West Okoboji lake showing distribution of *Ceratophyllum* (indicated by stipled areas. Survey stations shown by lines extending out from shore

The superiority of the bay habitat, over that of the open shore, for growth of this plant is indicated by the fact that nearly three-fourhs (72%) of its total acreage is found in the six [2] bays, which occupy but 32% of the entire lake. This is accounted for by the large proportionate area of water of suitable depth, substratum of mud rather than sand and gravel, and bottom slope gradual rather than abrupt. Table II gives the area of the respective bays and the acreage of *Ceratophyllum* in each. Millers Bay, in proportion to its size, has the largest number of acres of the plant. Browns Bay, while almost as large as Millers, supports only one-sixth as many acres. This is explained in part by the extensive beach of the former.

TABLE II

AREAS OF THE RESPECTIVE BAYS IN ACRES AND IN PERCENT OF TOTAL AREA OF LAKE. ACREAGE OF *CERATOPHYLLUM* AND PERCENT OF TOTAL IN EACH ALSO INDICATED

Bay	Area (Acres)	Percent Total Area of Lake	Acreage of Ceratophyllum	Percent Total Area Ceratophyllum
Emersons	377	9.95	107	24.6
Millers	131	3.45	87	20.0
North End	267	7.06	53	12.3
Smiths	273	7.20	35	8.1
Haywards	71	1.9	15	3.4
Browns	107	2.82	16	3.6
Totals	1226	32.38	313	72.0

ZONATION OF THE MAJOR VEGETATION

Zonation is, with few exceptions, apparent off the open shores but in the typical bay habitat it is not marked. Angiosperms are dominant in the bays, with the possible exception of Browns. During the summer those growing in the deeper water are not burdened with heavy loads of epiphytes but in the shallower portions the heavy growth near the surface is enmeshed and weighted down by the mats of blanket algae, chief of which is *Rhizoclonium*. The growth of the algae, to the harmful stage is usually attained during the first two weeks of July. Enormous beds of *Ceratophyllum* are found in Emersons and Millers Bays, Figure 2. In that part of Emersons traversed by the lines of stations, 175, 176, and 177 and in Millers Bay to the west and north of the reef, many other Angiosperms are intermixed. *Myriophyllum, Bidens, Ranunculus, Potamogeton natans, P. ampli-*

[2] The North End (from Eagle Point around to Pikes Point), by reason of depth, shore and substratum configuration very closely approaches the bay habit. It is here included as such, bringing the number of bays to six.

folius, P. pectinatus, P. zosterifolius, and occasionally *P. praelongus* in the deeper water, are the major plants found growing with *Ceratophyllum* in these areas.

The vegetation which parallels the shore of most of the open part of the lake exhibits, in general, three zones. The first zone extends from the water's edge to an average depth of about one meter. It contains very little vegetation and may therefore be called the shore zone. *Naias, Potamogeton pectinatus,* and *P. Richardsonii* are the seed plants which may be found in this restricted area and then only sparingly.

The second zone is dominated by *Chara* and hence will be called the *Chara* zone. Its inner limit corresponds quite closely to the outer shore zone and the depth limit of its outer margin is variable, ranging from as low as 0.7 m. at station 28 to 6 m. on the steep, sandy slopes near The Inn, stations 95-97. Most of the station records show *Chara* ending at a depth of 3-3.5 m., although it frequently extends to deeper levels. *Potamogeton Richardsonii, P. pectinatus,* and *Naias* are occasionally found growing in this zone.

Number three is the *Ceratophyllum* zone. The depth limits of its inner margin have an exceedingly large range, from 1-8 m. with an average of 3-3.5 m.; the outer vary from 2.5-8.5 m. and average 4.5-5 m. *Ceratophyllum* growing opposite open shores is usually very little intermixed with other macrophytic forms but *Potamogeton praelongus, P. pectinatus, P. zosterifolius, P. natans, Myriophyllum, Naias,* and *Tolypella, Nitella,* and *Chara* are sometimes found with it.

Ceratophyllum beds are areas of very dense vegetation (Figure 1). The semi-erect habit of the plant, together with the prolific production of lateral branches, operate to form veritable mats, the appearance of which has no doubt suggested one of the common names, "fish blankets." In addition to furnishing very effective protection to the fish, particularly the smaller ones, it serves them as a source of food, both direct and indirect.

CERATOPHYLLUM IN THE OKOBOJI REGION

Most of the ponds, marshes, and lakes of the Okoboji region were examnied during the summers of 1921-1923 for the presence of *Ceratophyllum.* Rush lake in Osceola County was also visited. The findings are given in Table III and agree quite well with those of J. L. Seal in the Iowa Lake Report.[3] The table includes

[3] Report of the State Highway Commission on the Iowa lakes and lake beds. 1 vol. text, pp. 1-250, 109 fig.'s; 1 vol. of 72 maps. Published by State. Des Moines, 1916.

more habitats of the Okoboji region than does the list of Mr. Seal, which justifies its inclusion here.

TABLE III

CERATOPHYLLUM IN LAKES, PONDS, AND MARSHES OF THE OKOBOJI REGION. LOCATION, UNLESS OTHERWISE INDICATED, IS IN DICKINSON COUNTY. T.—TOWNSHIP. R.—RANGE. DEPTH MEASUREMENTS ARE IN FEET. RELATIVE AMOUNTS OF *CERATOPHYLLUM*: —A—ABUNDANT. C.—COMMON. S—SCARCE

Lake, Pond, or Marsh				Ceratophyllum	
Name	Location	Area (Acres)	Maximum Depth	Abundance	Depth Range
West Okoboji	T. 99 N. R. 36, 37 W.	3788	132	A	3-27
East Okoboji	T. 99, 100 N. R. 36 W.	1875	24	S	2-5
Spirit	T. 100 N. R. 36 W.	5660	26		
Main body of lake				S	5-10
Arm projecting into Minnesota				C	2-5
Marsh adjoining lake east of Stony Point				S	1-1.5
Center	T. 99 N. R. 36 W.	264	15		
Diamond	T. 100 N. R. 37 W.	111	6		
Gar (Lower)	T. 99 N. R. 36 W.				
Gar (Upper)	T. 99 N. R. 36 W.			C	1-5
Gull Point Pond	T. 99 N. R. 37 W. Sec. 25	1	3	A	1-3
Hottes	T. 100 N. R. 36 W.	312	8		
Little Spirit	T. 100 N. R. 36 W. and Jackson Co., Minn. T. 100 N. R. 36 W.	724	12	A	1-5
Marble	T. 100 N. R. 36 W.	175	7		
Minnewashta (Middle Gar)	T. 99 N. R. 36 W.			?	
Pleasant	T. 99 N. R. 36 W.	82	6-7		
Prairie	T. 99 N. R. 36 W.	105	4-5		
Rush	Osceola Co. T. 100 N. R. 40 W.	317	4	S	1±
Silver	T. 100 N. R. 38 W.	1096	7-8		

TABLE III—*Continued*

Lake, Pond, or Marsh				Ceratophyllum	
Name	Location	Area (Acres)	Maximum Depth	Abundance	Depth Range
Swan	T. 100 N. R. 35 W.	298	3	S	
Main body of lake					1±
Marsh adjoining lake on N. W.				C	1±
Welch	T. 100 N. R. 37 W.	57	6		

The above table shows *Ceratophyllum* to be found in only eleven of the twenty-one listed habitats. Judged by depth, shore configuration, and substratum slope and composition, many of those which do not support the plant should be just as favorable to it as those which do. The outstanding cause of the rather restricted distribution is cloudiness of the water to such a degree that penetration of light sufficient for photosynthesis is prevented. Plankton growth is chiefly responsible for this situation but agitation of the bottom by wave action is also found to be operative in some of the shallower bodies of water. A second factor unfavorable to *Ceratophyllum* is the substratum of sand and gravel found in many of the smaller lakes.

The clear water and large amount of mud substratum at suitable depths in West Okoboji lake make it the best habitat in the Okoboji region for the growth of *Ceratophyllum*.

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